2022 Memo Report: Seafloor Mapping of Fore Points Marina, Vicinity of Casco Bay, Portland Harbor

Chief of Party – Peyton Benson, Project Hydrographer, Contractor to the Maine Coastal Program

Project Manager – Claire Enterline, Research Coordinator, Maine Coastal Program

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Acknowledgements

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Contents

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ABSTRACT

On January 20 of 2022, the Maine Coastal Mapping Initiative (MCMI) conducted hydrographic surveying using a multibeam echosounder (MBES) in marine waters in Portland Harbor, Maine, focusing on the locus of Fore Points Marina. The surveying efforts were conducted as an exercise in deploying newly reconfigured equipment and may be used to support the Department of Marine Resources' (DMR) efforts to enhance coastal resiliency through identification, characterization, and protection of potential critical fisheries to the state's marine environment and economy, pending further accuracy verification of crosslines later in the survey season. The survey also coincides with state and federal efforts to update coastal data sets and may be used to increase high resolution bathymetric coverage for Maine's coastal waters. A total of 118134 m^2 (0.046 mi^2) of high-resolution multibeam data were collected in the vicinity of Casco Bay; Portland Harbor and depths in the area surveyed ranged from 1 to 13 meters (referenced from Mean Lower Low Water). The morphology of the seafloor is characterized mainly by a flat muddy bottom which slopes steeply (~20°) from 4m to 8m to the southeast (and further to 13m at the southeastern terminus). Additionally, a small alongshore channel, roughly 30m across and 4m deep (referenced to surrounding seafloor) is present across the extent of the dataset. Throughout the dataset are a series of 150+ concrete anchors of two discrete sizes embedded in the substrate and covered in assumed depositional mud and/or biofouling which are connected to floating docks by chains also obscured by biofouling. Further investigation would be needed to determine precise composition of said materials through ground-truthing, as such methods were not within the scope of this project. All assumptions of seafloor composition are based on visual morphology and backscatter returns and have not been verified with ground-truthing efforts.

1.0 Area Surveyed

The survey area consists of a roughly 0.05 mi^2 region directly adjacent to the northwestern tip of the Portland city peninsula, within which, the entirety of the Fore Points Marina dockage lies. This survey area falls into the vicinity of Casco Bay, in the sub-locality of Portland Harbor seen in Figure 1. The data collected overlaps existing data last collected by NOAA 2012 (NOAA survey registry number H124794 (Figure 1). These data were not collected in direct accordance with the *NOS Hydrographic Surveys Specifications and Deliverables* and the *Field Procedures Manual* requirements; however, both documents were referenced during acquisition for guidance.

Survey limits are listed in Table 1

Table 1 – 2022 survey limits

Casco Bay; Portland Harbor – Fore Points Marina

Southeast Limit	**Northwest Limit**
43° 39’ 52.11” N	43° 39’ 37.23” N
70° 14’ 19.55” W	70° 14’ 25.94” W

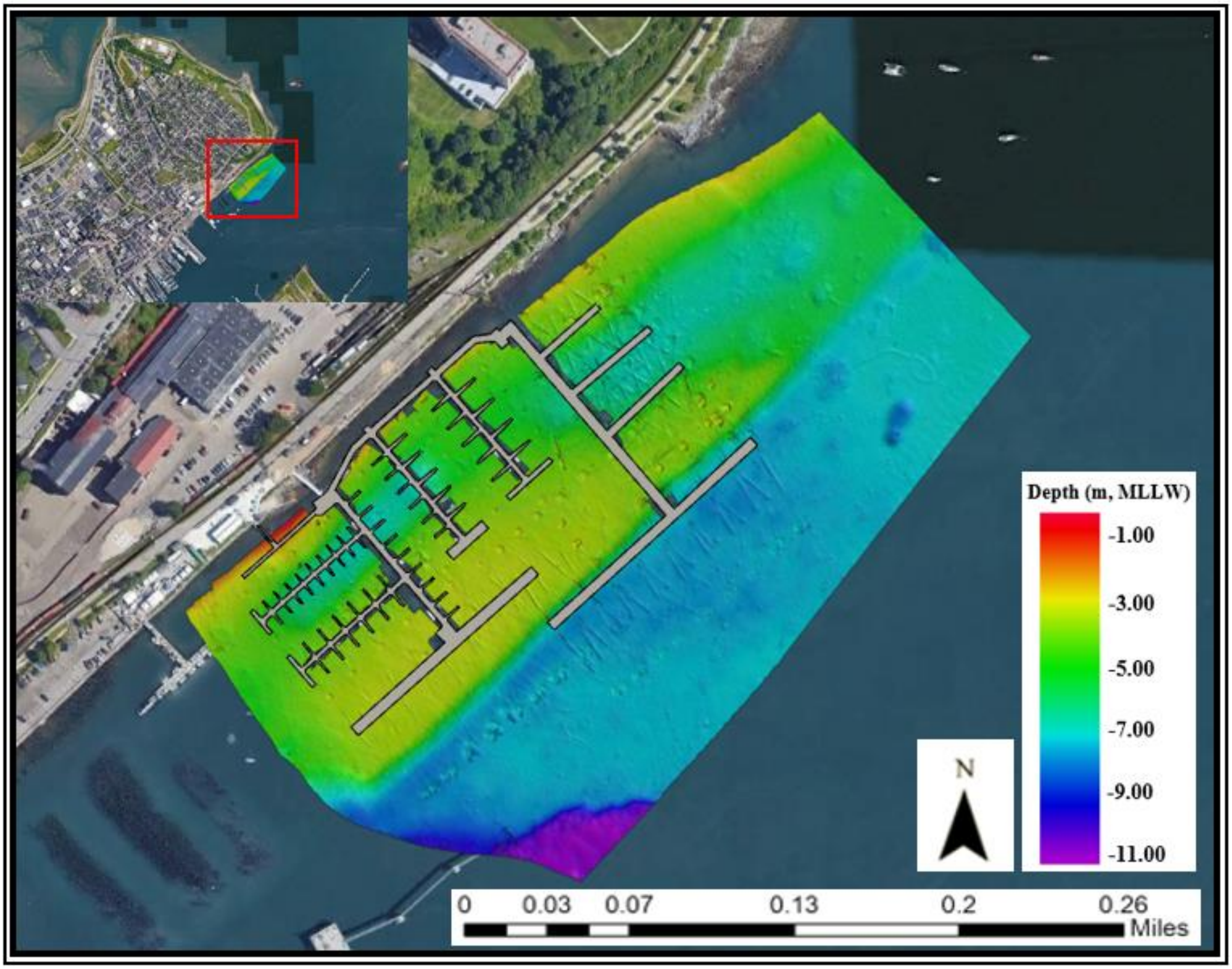

Figure 1 – Shaded relief bathymetry of 2022 MCMI Fore Points Marina survey coverage atop Google Earth satellite imagery with dock outline superimposed. Data is gridded at 25-centimeter resolution and colored by depth with 'hot' colors indicating shallow soundings and 'cold' colors indicating deeper soundings.

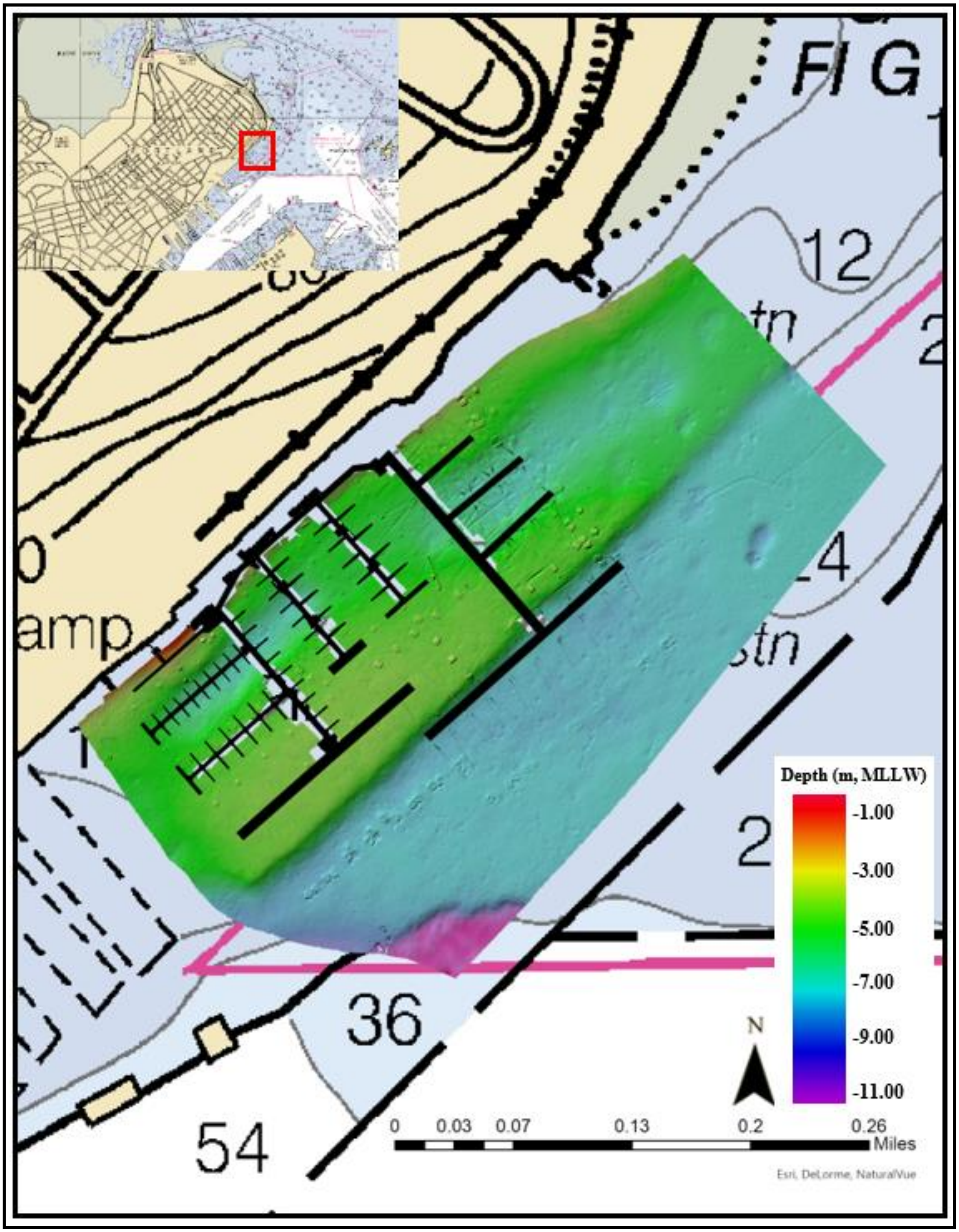

Figure 2 – Shaded relief bathymetry of 2022 MCMI Fore Points Marina survey coverage atop NOAA chart 13292 with dock outline superimposed. Data is gridded at 25-centimeter resolution and colored by depth with 'hot' colors indicating shallow soundings and 'cold' colors indicating deeper soundings.

1.1 Survey Purpose

This survey was conducted by the Maine Coastal Program's Maine Coastal Mapping Initiative (MCMI) as part of a multi-agency cooperative agreement partially funded by the National Oceanic and Atmospheric Administration (NOAA) Office of Coastal Management, the Maine Department of Marine Resources (DMR), The Nature Conservancy (TNC), Maine Inland Fisheries & Wildlife's State Wildlife Grant, and the Maine Outdoor Heritage Fund. The purpose of this project is to help inform policy decision-making related to Maine's coastal waters by increasing the volume of available high-quality bathymetric, benthic habitat, geochemical, and geologic data in the vicinity of Casco Bay. This project also coincides with state and federal efforts to update coastal data sets for Maine's coastal waters and provides new data in the areas covered by National Oceanic and Atmospheric Administration (NOAA) nautical charts 13260, 13288, and 13292 in Casco Bay. These data were acquired and processed to meet Office of Coast Survey bathymetry standards as best as possible and are shared with the NOAA Office of Coast Survey for review.

1.2 Survey Coverage

Holidays (gaps in MBES coverage) in this dataset occurred because of limitations in swath-width in extremely shallow waters coupled with non-navigable portions of this survey area preventing complete coverage. Floating docks and vessels in slips prevented full overlap of data in portions of the collected dataset and are visible as rectangular empty spaces in the data provided. Analyses of bathymetric data show that the least depths were achieved over all features, and that holidays have not compromised data integrity. All but two small slips have bathymetric and backscatter data regardless of occupation by other vessels, but overlap could not be achieved on either side of the docks in some cases.

2.0 Data Acquisition

The following sub-sections contain a summary of the systems, software, and general operations used for acquisition and preliminary processing during the 2022 survey season.

2.1 Survey Vessel

All data were collected aboard the Research Vessel (R/V) Amy Gale (length = 10.7 m, width = 3.81 m, draft = 0.93 m) (Figure 3), a former lobster boat converted to a survey vessel and contracted to the MCMI. The vessel was captained by Caleb Hodgdon of Hodgdon Vessel Services based out of Boothbay Harbor, Maine. The EM2040C transducer, motion reference unit (MRU), AML MicroX surface sound speed probe, and dual GNSS antennas were pole-mounted to the bow; pole raised (for transit) and lowered (for survey) via a pivot point at the edge of the bow. The main cabin of the vessel served as the data collection center and was outfitted with four display monitors for real time visualization of data during acquisition.

Figure 3 – R/V Amy Gale shown with pole-mounted dual GPS antennas, Kongsberg EM2040C multibeam sonar, MRU (not visible), and surface sound speed probe (not visible) in acquisition mode

2.2 Acquisition Systems

The real-time acquisition systems used aboard the R/V Amy Gale during the 2021 surveys are outlined in Table 2. Data acquisition was performed using the Quality Positioning Services (QPS) QINSy (Quality Integrated Navigation System; v.9.2.2) acquisition software. The modules within QINSy integrated all systems and were used for real-time navigation, survey line planning, data time tagging, data logging, and visualization.

Table 2 – Major systems used aboard R/V Amy Gale

Sub-system	Components
Multibeam Sonar	Kongsberg EM2040C and processing unit
Position, Attitude, and Heading Sensor	Seapath 330 processing unit, HMI unit, dual GPS/GLONASS antennas, MRU 5-V motion reference unit (subsea bottle), Fugro 3610 Receiver and AD-341 antenna
Acquisition Software and Workstation	QINSy software v. 9.2.2 and 64-bit Windows 10 PC console
Surface Sound Velocity (SV) Probe	AML Micro X with SV Xchange

Sound Velocity Profiler (SVP)	Teledyne Odom Digibar S sound speed profiler
Ground-truthing/Sediment Sampling Platform	Ponar grab sampler, GoPro Hero 3+ video camera, GoPro Hero 5 Black video camera, dive light, dive lasers, YSI Exo I sonde

3.0 Quality Control

3.1 Crosslines

Crosslines have not been conducted as of the writing of this report. The inshore area ensonified does not allow for crosslines due to orientation of collected lines and nearshore obstacles such as floats and pilings.

3.2 Junctions

Junctions have not been calculated for collected datasets as the survey season remains to be completed. At the end of data collection, junction surfaces will be created and submitted with the data in these surveys

3.3 Equipment Effectiveness

Sonar

Sonar data were acquired with a Kongsberg EM2040C set to a survey frequency of 300 kHz, high-density beam forming, with 400 beams per ping. Although the EM2040C allowed full swath widths at this frequency, lines from previous years' survey run at comparable depths contained considerable noise in outer beams (> ±60 degrees from the nadir as identified by QPS engineers). As a result (and as per QPS recommendation), soundings greater than ±60 degrees from the nadir were not included in final bathymetric surfaces.

3.4 Sound Speed Methods

Sound speed cast frequency: A total of 3 sound speed casts were taken throughout the survey period for this project. All sound speed cast measurements were collected using the Teledyne Odom Digibar S profiler. Sound speed casts were taken as needed throughout the survey, which was generally when the observed surface sound speed (monitored and visualized in real-time using the AML MicroX SV sensor) differed from the surface sound speed in the active profile by more than 2 meters per second. In certain instances, supplemental casts were taken when there was reason to suspect significant changes in the water column (e.g. change in tide, abrupt changes in seafloor relief, etc.). During the collection of sound speed casts, logging was stopped to download and apply the new cast and was resumed when the boat circled around and came back on the survey line. Throughout the duration of the survey, the surface sound speed was observed in real-time (by the AML Micro X SV probe). Although sound speed data were recorded in raw sonar files, the raw sound velocity profiles (.csv) were also submitted with the survey data.

A quality comparison between the AML Micro X SV sensor and the Teledyne Odom Digibar S profiler was not performed. However, real-time comparisons between surface sound speed observed by the AML Micro X SV and the surface sound speed entry in the Digibar S profile suggested these instruments were in agreement throughout the survey period.

4.0 Data Post-processing

The following is a summary of the procedures used for post-processing and analysis of survey data using Qimera (v.2.4.0, 64-bit edition), FMGT (v7.10.0, 64-bit edition), Fledermaus (v.8.4.0, 64-bit edition), and ArcGIS Pro (v.2.9.1) softwares.

4.1 Horizontal Datum

The horizontal datum for these data is WGS 84 projected in UTM zone 19N (meters).

4.2 Vertical Datum and Water Level Corrections

The vertical datum for these data is mean lower-low water (MLLW) level in meters. A tidal zoning file ("Maine_Tide_Zoning.zdf") containing time and range corrections for verified tide station data was provided by NOAA OCS to MCMI in May 2020. This file was used to apply time corrections, tide height offsets, and tide scale (range) for collected data in each zone listed in Table 3.

Table 3 – Tide zones and corrections referenced to verified Portland, ME (8418150) tide station data

Survey Area	Tide Station	Zone ID	Time Correction (mins.)	Tide Scale
Marina	8418150	ME30	18	1.0
		ME31	6	0.99
		ME38	36	0.99
		ME61	6	1.0
		ME65	6	0.99
		ME70	12	0.96
		ME74	30	0.96
		ME84	6	0.96
		ME86	0	0.98
		ME96	18	0.96

4.3 Processing Workflow

The general post-processing workflow in Qimera was as follows:

1. Create project
2. Add raw sonar files (e.g. metadata extracted and processed bathymetry data converted to .qpd, including vessel configuration and sound velocity)
3. Add tide zoning file (.zdf) and associated tide data and integrate into raw files
4. Create dynamic surface with NOAA CUBE settings enabled for desired resolution (e.g. 2-meter, 4 meter)
5. Review and edit soundings/clean surface with slice editor tool, 3D editor tool, and available filters
6. Duplicate surfaces at other grid sizes, if desired
7. Export final surface to .BAG file and CUBE surface
8. Export processed data in .GSF format for backscatter processing

<u>CUBE</u>

A CUBE (Combined Uncertainty and Bathymetry Estimator) surface was created for editing and as a starting point for final products. The corresponding NOAA cube setting (e.g. "NOAA_4m" configuration, Figure 4) was selected for each surface depending on the grid size of the surface.

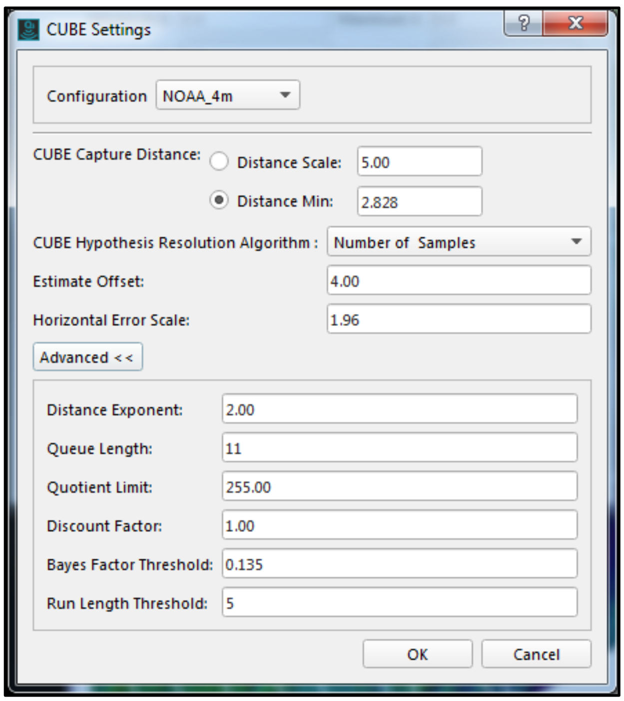

Figure 4 – CUBE settings parameters window shown with settings for NOAA 4-meter grid resolution

4.4 Final Surfaces

The following surfaces, .BAG, and .KMZ files were submitted with the survey data and can be seen in Figures 1, 2, 7, & 8 and in Table 4.

Table 4 – Surfaces produced from 2022 survey data

Surface Name	Resolution (m)	Depth Range (m)
ForePoints_25cm_MLLW_verified.bag	0.25	1 - 13
ForePoints_50cm_MLLW_verified.bag	0.50	1 - 13
ForePoints_25cm_bathymetry.kmz	0.25	1 - 13
ForePoints_25cm_MLLW_verified.surface	0.25	1 - 13
ForePoints_50cm_MLLW_verified.surface	0.50	1 - 13

4.5 Backscatter

Backscatter was logged in the raw .db files. The .db files also hold the navigation record and bottom detections for all lines of surveys. Processed sonar files containing multibeam backscatter data (snippets and beam-average) were exported from Qimera v.2.4.0 in .GSF format. QPS Fledermaus Geocoder Toolbox (FMGT; v.7.10.0, 64-bit edition) was used to import, process, and mosaic time-series backscatter data. Default backscatter processing settings were used to create the mosaic, except for the Angle Varied Gain (AVG) filter and AVG window size, which were set to ‘Adaptive’ and ‘100’, respectively. Backscatter mosaics of the data were gridded at 25-centimeter and 50-centimeter resolution for the Fore Points Marina dataset. Mosaics were exported in floating-point GeoTIFF format and as a .KMZ. The mosaics are shown in Table 5 and Figure 5.

Table 5 – Backscatter mosaics produced from 2022 survey data

Mosaic Name	Pixel Size (m)
ForePoints_25cm_backscatter_fpgt.tif	0.25
ForePoints_50cm_backscatter_fpgt.tif	0.50
ForePoints_50cm_backscatter.kmz	0.50

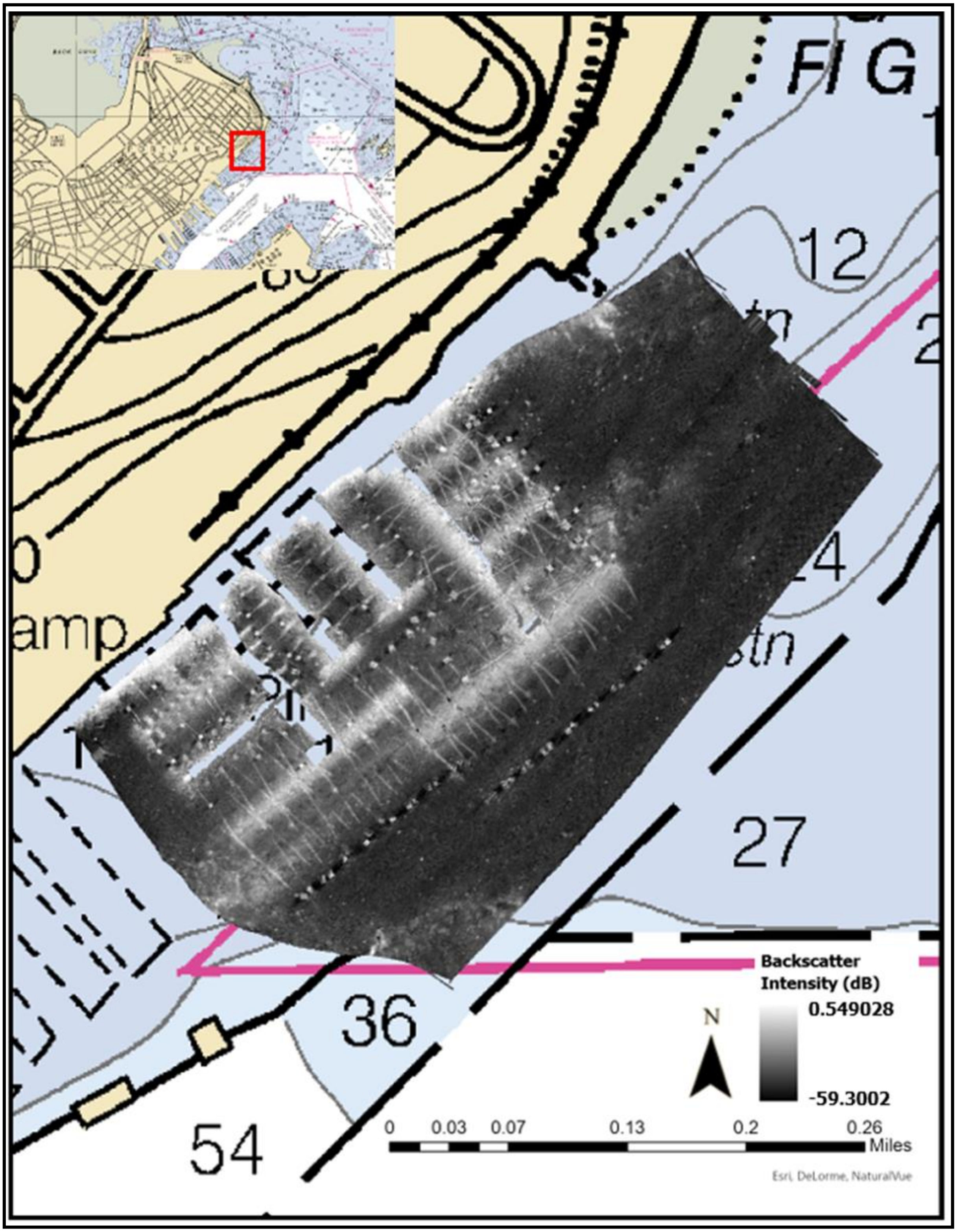

Figure 5 – Backscatter imagery of 2022 MCMI Fore Points Marina survey coverage atop NOAA chart 13292. Backscatter returns were color-normalized on a black-white scale based on 3-sigma limited data with stronger returns denoted by brighter coloration and softer returns displayed darker. Dock outline omitted for data visualization.

4.6 Contours

Contours were created for this dataset to quickly identify and visualize depths in areas of interest. Processed and corrected dynamic surfaces were exported as .bag files and imported to ArcGIS Pro 10 (v2.9.1). The elevation band was extracted to a raster layer and then contoured at 1m intervals with bathymetric color scaling. Contour files have been provided which can be viewed readily in Google Earth Pro software. Additionally, a dock outline established from Google Earth satellite imagery has been provided for reference among other surfaces delivered. Smaller interval contours can be provided upon request.

Table 6 – Contour line files produced from 2022 survey data

Contour Name	Contour Interval (m)
ForePoints_Contours_1m.kml	1.00
ForePoints_Contours_50cm.kml	0.50
ForePoints_Contours_Filled_1m_km	1.00
ForePoints_Dockage.kmz	N/A

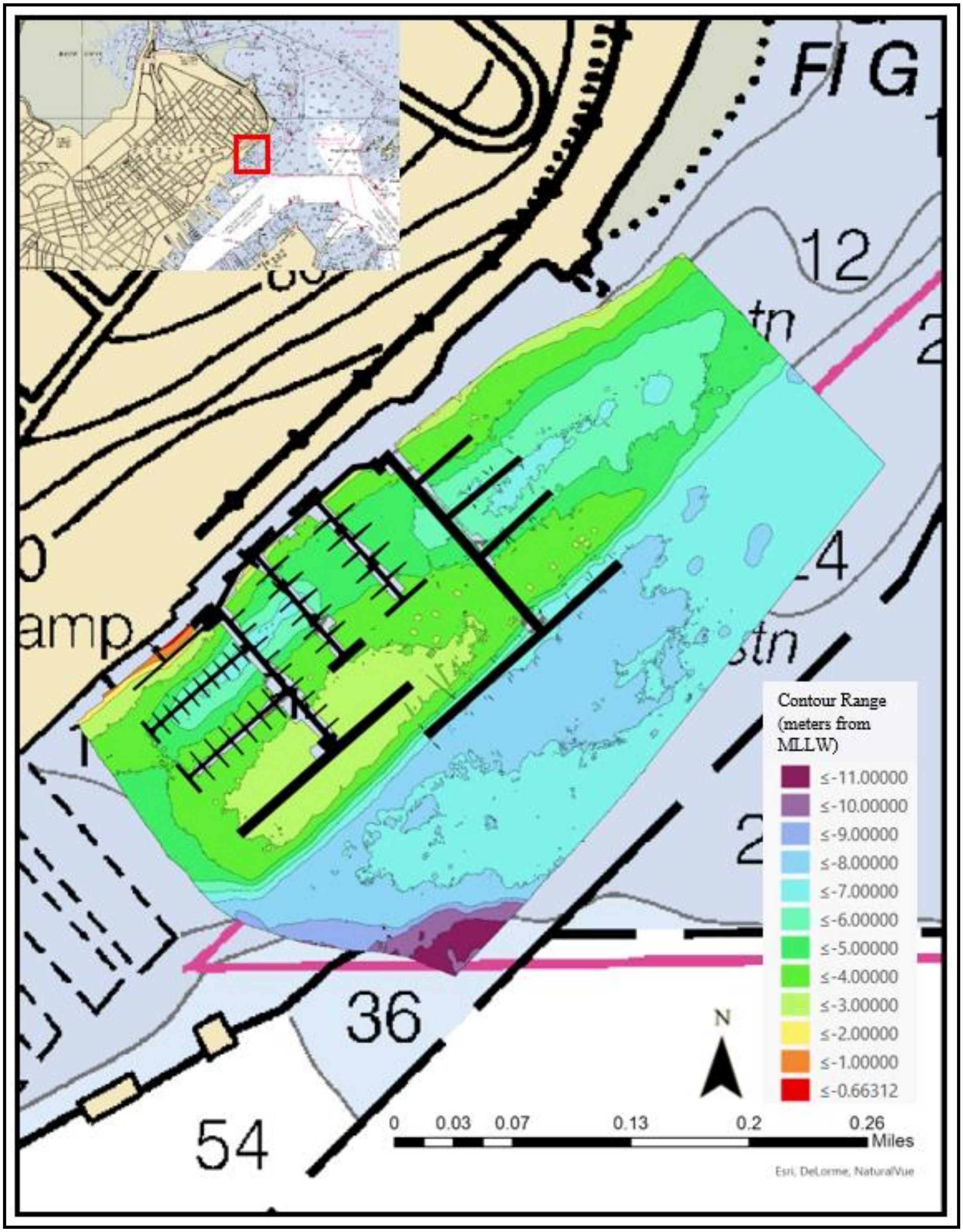

Figure 6 – Contour depth map of 2022 MCMI Fore Points Marina survey coverage atop NOAA chart 13292. Contour intervals shown are spaced at 1m depths, excepting depth displaying shallowest sounding.

5.0 Discussion

5.2 Bathymetry and Characteristics of Seafloor

Depths throughout the dataset ranged from 1 to 13 meters (approximately 3 to 43 ft), with the shallowest soundings found nearshore and progressively increasing in depth to the Southeast. Deepest soundings were found in the Southeastern corner of the dataset. All depth readings within slips were found to be more than 3.5 meters, with the shallowest depths located in the vicinity of the floating breakwaters. This region exhibits a generally consistent, flat, elevated plateau of roughly 3.5 – 4-meter depths, which orient in the Northeast-Southwest direction. When viewed from afar, this structure appears as a submerged outcropping which splits a nearshore channel from the main Portland Harbor channel. Orientation of the large, suspended breakwaters would indicate that the presence of these wave-preventive measures are sustaining a longshore submerged berm, with a deep main channel to the east, and creating a shallower channel shoreward. The presence of the breakwaters forces the water around them to the East and West, which is evidenced by the increased rate of sediment removal from either side of the breaks. Consequently, the deepest depth soundings within the confines of the docking area were found in the small shoreward channel (roughly 30 meters wide) which runs in the longshore direction along the entire dataset at approximately 7 meters. The majority of slips are found within this area, and evidence suggests these depths would continue to increase gradually over time.

The morphology of the seafloor in this area is characterized mainly by a mud substrate speckled with over 150 anchor points and chains connected to the floating docks. Backscatter return values indicate nearly the entire region consists of a soft sediment such as mud or sandy mud, with no hard bottom found aside from the anchor points. The morphology of the survey area is consistent throughout and in moving from Northwest to Southeast, it exhibits a narrow shelf which gently slopes into a shallow channel before rising to an elevated berm, where it finally drops steeply to the main channel of Portland Harbor. While seafloor substrate can be inferred from backscatter return values, no claims about sediment composition can be confidently made without ground-truthing in the survey area. Further investigations would need to be carried out to deliver conclusions on seafloor composition concerning grain size in this locus.

6.0 Summary

A total of 118134 m^2 (0.046 mi^2) of high-resolution multibeam data were collected in the vicinity of Casco Bay, sub-locality of Portland Harbor by MCMI on January 20, 2022. Except holidays induced by non-navigable portions of the survey area, multibeam coverage was 100% in all areas surveyed. Bathymetry and backscatter data products were produced at both 25-centimeter and 50-centimeter grid resolutions and contour surfaces were provided with 50-centimeter and 1-meter intervals, respectively.

These data were acquired and processed to meet Office of Coast Survey bathymetry standards as best as possible and will be shared with NOAA OCS for review for expected revision of nautical charts.

Please contact the Maine Coastal Mapping Initiative for additional information or data requests.

References

NOAA, 2021. NOS hydrographic surveys specifications and deliverables: U.S Department of Commerce National Oceanic and Atmospheric Administration. 162 pages.

U.S. Department of the Interior, 2014. Proposed geophysical and geological activities in the Atlantic OCS to identify sand resources and borrow areas north Atlantic, mid-Atlantic, and south Atlantic-Straits of Florida planning areas, *final environmental assessment.* OCS EIS/EA BOEM 2013-219 U.S. Department of the Interior Bureau of Ocean Energy Management Division of Environmental Assessment Herndon, VA, January 2014.

Appendix A: Objects of Interest

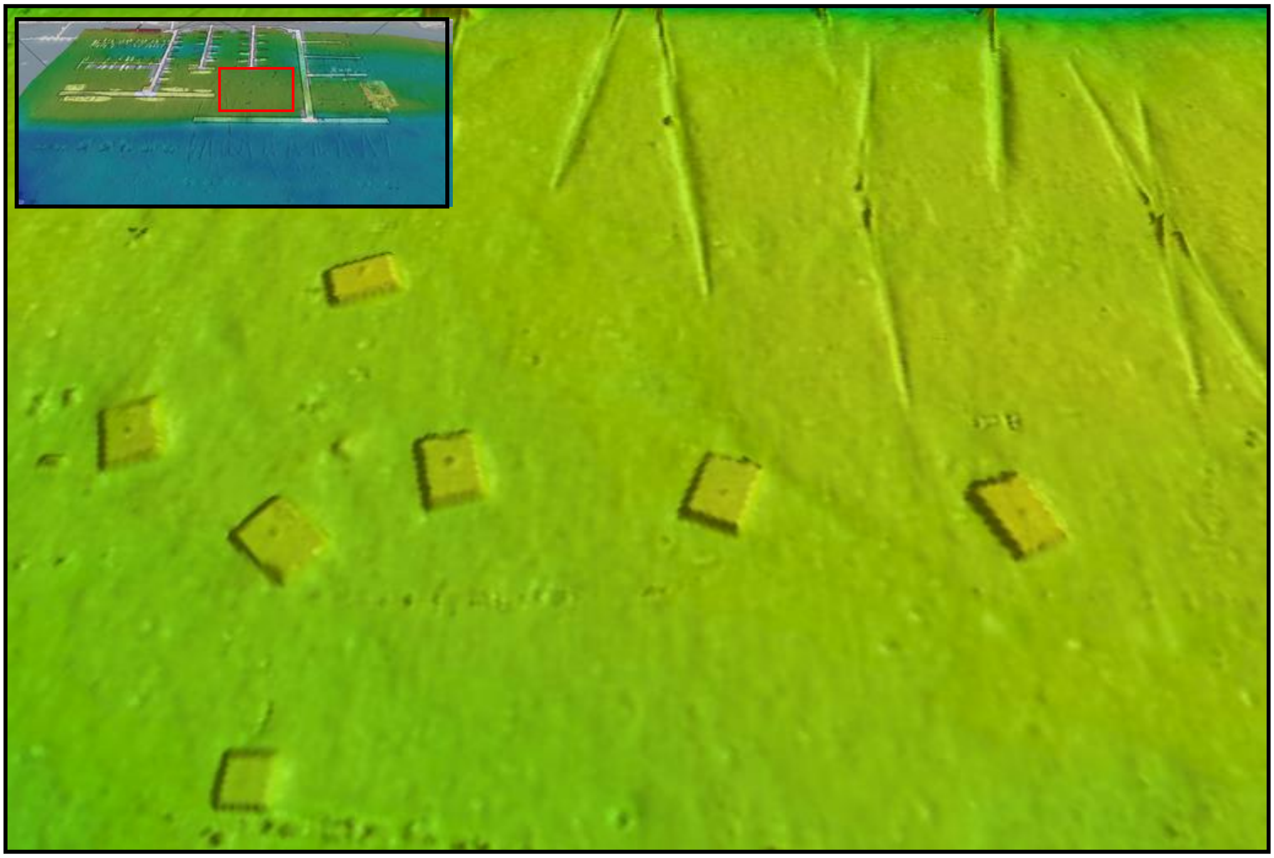

Figure 7: Oblique angle view of anchors and chain lines with low deposition.

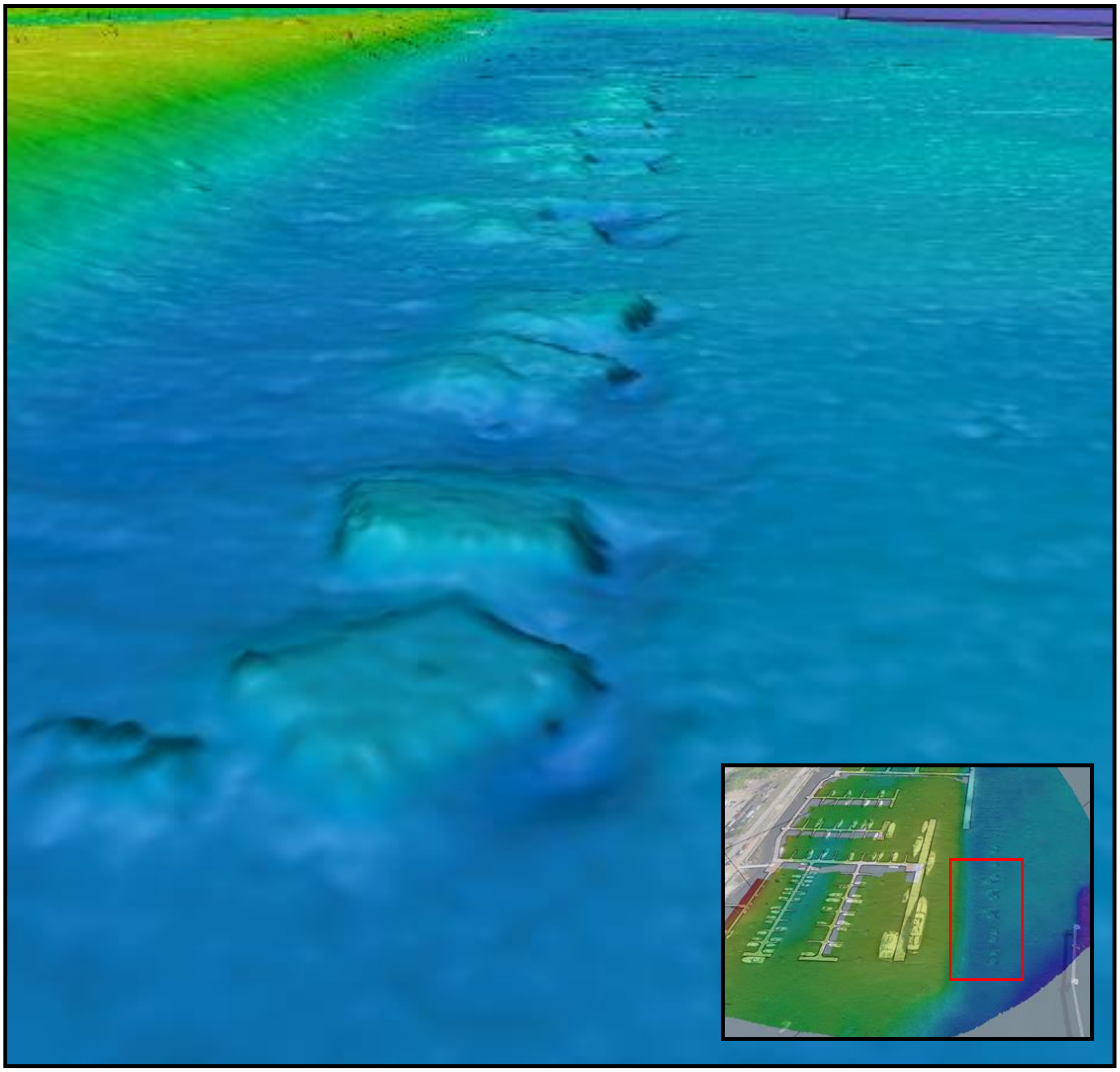

Figure 8: Oblique angle view of anchors off the southeastern shelf. These anchors demonstrate significantly more deposition and evidence of high-energy wave action.